DO ANTS FORM PRACTICAL JUDGMENTS?

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Scattered through the literature are several records of observations which indicate that ants form what Hobhouse calls practical judgments. However, recent comparative psychologists favor the casting of such evidence out of court, because it was not obtained from experiments conducted under proper conditions of control. Lubbock[1] experimented upon the subject with negative results. The first two bits of evidence reported in this communication are reports of mere observations; the only excuses for recording them are that the observations were made in the laboratory and that they confirm the records of similar observations made by others in the field; the third, however, is the result of a carefully planned and controlled series of experiments.

For several months I have had in one of the laboratories of the University of Chicago a colony of *Camponotus herculeano-ligniperdus*, consisting of nine winged females and about twice as many workers.[2] The Janet nest in which the ants were housed contained a row of three compartments (Figs. 1 and 2; *A*, *B*, *C*). The entrance to this nest (Fig. 1, *E*) was about one centimeter wide by two centimeters high. For several weeks no obstructions of any sort were placed by the ants in that entrance, although a large amount of litter was kept upon the island at all times. An ant usually mounted guard in the entrance *E* and similar guards were usually stationed in the tunnels connecting compartment *C* with compartment *B* and compartment *B* with compartment *A*. For over two months I examined the nest several times daily and in over ninety per cent. of the times I found guards located in the places mentioned.

In the course of some experiments upon an entirely different problem I had occasion to fight the guard stationed in the entrance

[1] Lubbock, "Ants, Bees and Wasps," London.

[2] To prevent the experiments recorded in this paper from being invalidated by mice, all holes leading into the room were filled with plaster of paris and the door was kept locked whenever I was absent.

E (Fig. 1) with dissecting needles and glass rods. Sometimes I used plain needles or glass rods, at others needles or rods that had been moistened with oil of cedar or oil of cloves. Each time the fight was continued until the ant retreated into the innermost part of the nest. After these maneuvers had been repeated several times daily for about a week, the guard withdrew from the entrance *E* and the ants plugged that passage-way with detritus, composed of bits of wood and bread from the island, trash from the interior

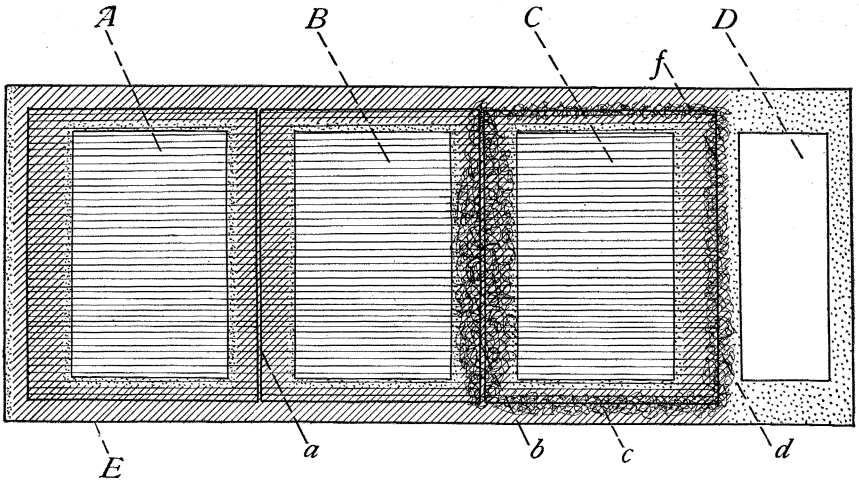

FIG. 1.

of the nest and cotton stripped from the turkish toweling of the nest. For five months thereafter the nest was examined from five to ten times every day, but no ant was observed as a guard, in either entrance *E* or the tunnels connecting the apartments until August 10, 1907. Since then they have been mounting guard as regularly as they did before they plugged the entrance.

On the same Lubbock island with the above-mentioned *Camponotus-herculeano-ligniperdus*, I had a large colony of *Formica fusca* var. *subsericea* Say. The island was kept littered with detritus of various kinds. One day I noticed a worker of this colony begin the construction of a bridge across the ditch of water that surrounded the island on which the colony was located. This partial bridge was constructed in the following manner. The ant placed a piece of charred paper about one centimeter wide

upon the water on the inner side of the ditch. After walking out upon this bit of paper and reaching outward with its antennæ, the ant returned to the island and picked up a crumb of bread crust three millimeters wide. The ant then walked across the charred paper and placed this bit of bread upon the water just beyond and adjacent to the paper. After standing for a short time upon the outer edge of the crumb and reaching outward with its antennæ, the ant returned to the island and picked up a piece of wood two millimeters wide by three millimeters long. This the ant placed upon the water just beyond and adjacent to the crumb. Thus there was constructed, extending three fourths of the distance across the ditch, a bridge of three elements. Upon the outer terminus of this partial bridge the ant stood for fully two minutes, reaching continually outward with its antennæ. The bridge was never completed.

The third bit of evidence was afforded by a series of experiments performed upon the same colony of *Formica fusca*. This colony, consisting of three wingless perfect females and about two hundred workers, was brought into the laboratory September 27, 1906. It was from the sidewalk of one of the streets of Chicago, where it was located partly beneath the stone and partly in the trash that the ants had heaped up along the edge of the stone. The sidewalk, which was several years old, was composed of concrete stones at least a yard square and fully six inches thick. The stones of this particular pavement were free from cracks of all kinds. In the laboratory the ants were kept in a nest of the type described above. Compartments *C* and *B* were covered with orange glass and compartment *A* with colorless glass. Throughout all of the experiments the Lubbock island upon which the nest was located was kept littered with bread crumbs, bits of wood, small pieces of egg shell, partially burned matches, charred paper, cotton, etc. For nearly three months the ants of the colony were the subjects of daily experiments upon the sense of hearing, etc. After that, for several weeks, the ants were left to themselves, but the nest was carefully scrutinized several times every day. At all times some workers would be found in apartment *B*, but the fertile females and the majority of the workers used compartment *C* (Fig. 1) as a living room. Whatever booty the ants captured was always carried into this chamber.

On the twenty-sixth of December, 1906, I discovered three batches of newly laid eggs in the living chamber. For several days prior to this discovery, an ant from the nest had been busy covering crack *b* (Fig. 1.) with detritus obtained from the island. At first only one ant was thus occupied. Later in the day a second ant joined this one. On some days three and on others four ants were thus engaged. These ants worked on for about two weeks and covered not only crack *b* but also the edges, *d*, *c*, *f* (Fig. 1), in the order named. Crack *b* received the largest amount of trash, edge *d* the next largest amount, while the edges *c* and *f* each received about an equal amount. The ants covering these cracks sometimes obtained the trash from one place on the island and sometimes from another; thus all the trips of the same ant were not made along the same path. Not only so, but the same ant often went to the trash pile along one path and returned to the crack along another.

In this particular experiment the glass cover over *C* reached much nearer the edge of the well than is shown in the illustration, which was drawn from another experiment of the same kind. Indeed, it entirely covered the turkish toweling on the well side of the living chamber. As a result of this, when the ants began to cover the edge *d* with trash, it would fall down into the well. This continued for nearly three days and by that time the well contained quite a collection of bread crumbs, bits of wood, and the charred ends of matches. About the close of the third day, the ants stopped carrying heavier debris and began covering the edge *d* with fibers of cotton shredded from the layer of cotton upon which the nest rested. They continued to add cotton fibers for about a day, at the end of which time they recommenced adding wood and bread crumbs to the pile. This time, owing to the presence of the cotton fibers this coarser detritus remained where placed. I do not feel justified in attaching much significance to the fact that after the other detritus failed to remain on the crack the ants covered it with cotton fibers and then resumed carrying heavier materials; for the cotton was all brought from a side of the nest upon which there was no other detritus and it may have been that the ants happened to go to that side for detritus and, finding cotton in abundance, continued to return to that side for material.

While these one to four workers were busy covering the cracks surrounding compartment *C*, yet others were busy filling compartment *A* (Fig. 1) with trash. A large number of workers assisted in filling compartment *A*, hence it was not long before this compartment was almost completely filled with trash and the entrance *E* so reduced in size that it was necessary to enlarge the opening whenever occasion arose to carry large pieces of captured food to those within the nest.

On an adjacent island I had a colony of the same species of ants in which there were no fertile females. In the early part of May these neuters began to lay eggs. Immediately compartment *A* was filled with trash.

Since the glass covering compartment *A* is colorless we must look upon the detritus placed there as trash heaped about the entrance to the nest. That the formation of such a trash pile about the opening of the nest is a common breeding habit or instinct is evidenced by the fact that in nature trash piles are found about the openings of many of the nests of this species. In the early spring I have frequently noticed such trash piles in the process of formation. They are composed partly of dirt brought from within the nest and partly of trash gathered from the surrounding territory. In a region where this species of ants is common, a careful search in the early spring is certain to reveal several such trash piles in the process of construction. In almost every case observed by me, a few ants were busy collecting trash from the outside and dropping it about the nest opening, while a larger number of ants were bringing dirt from the interior and heaping it about the same opening. It would then be illogical to consider the trash stored away in compartment *A* as anything more than the homologue of the trash pile that this species frequently builds about the entrance to its normal nests.

To me it does not seem logical to group the four piles of trash covering crack *b* and the edges *c*, *d*, *f* (Fig. 1) in the same category, for neither of these trash piles surrounded an entrance into the nest: *b*, the nearest of these piles, was at least seven inches from *E*, which was the only opening into the nest. Since this colony and its immediate ancestors had lived for several generations under the paving stones mentioned it is unlikely that either

they or their immediate ancestors had ever experienced a nest with a crack leading into the brood chamber.

To make sure that the covering of the cracks mentioned above was not a mere coincidence, I removed gently the trash that was covering crack *b*. In less than an hour a few ants were busy covering it. At intervals of about a week, this experiment was repeated twelve times; always yielding the same results. Usually one or two ants did the covering; at no one time have I seen more than four thus occupied.

That the ants were bent not on covering just any cracks that entered the nest, but only the cracks that affected the brood chamber is evidenced by the fact that, although these experiments covered a period of eight months, at no time did the ants cover the crack *a* or the free edges of the glass covers of compartments *A* and *B* (Fig. 1). Furthermore ants bearing trash would frequently cross the edges of the covers to *A* and *B* and even the crack *a* and pass on and deposit their burdens on the crack *b* or the edges *c*, *d*, or *f*. There is yet another evidence of this statement.

If this behavior is for the purpose of covering cracks the existence of which alters the conditions in the brood chamber, a crack crossing the brood chamber should produce a greater disturbance and hence should be covered by the ants first. Therefore I divided the cover to the living chamber *C* into two equal parts which were so adjusted as to leave between them a transverse crack *e* (Fig. 2) wide enough to make quite an opening yet too narrow to permit the passage of ants to and fro. Whenever this was done, and it was repeated over a dozen times, the first crack to be covered was *e*, and after *e*, *b* (Fig. 2). In each case only a few ants covered the cracks. Usually only one or two were thus employed; at no one time were over six thus occupied. Remember that that nest contained at least two hundred workers.

Whenever the trash was removed from crack *e* (Fig. 2), were it done ever so gently, the induced restlessness of the ants within the nest indicated that they were much disturbed. If I gently breathed against the uncovered crack, the ants within rushed about in all directions as though panic stricken. To one who

has watched this ant (*Formica fusca* var. *subsericea*) when outside the nest continue its work even when a breeze was blowing, the pronounced agitation caused by such a slight draught is sure to appear striking. It is, however, in harmony with observations, recorded in a former paper, upon the effect of sound and light

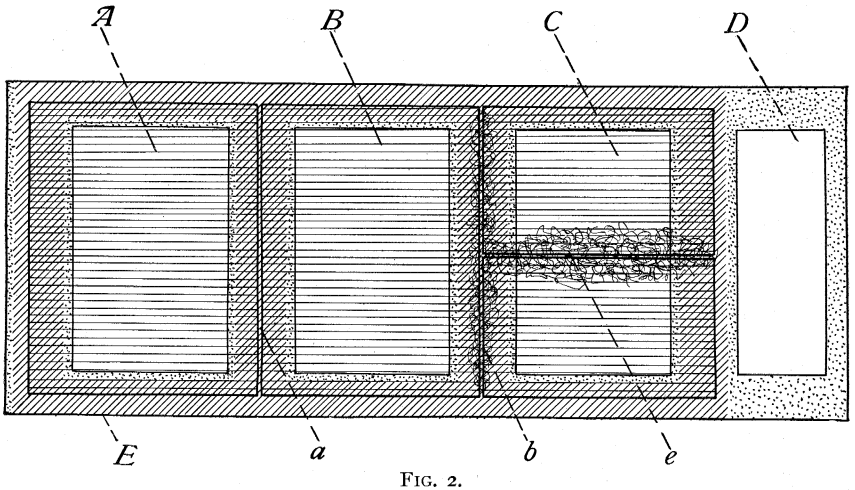

FIG. 2.

upon ants. It seems that the same lights and sounds and draughts which scarcely call forth any response when encountered without the nest, induce quite vigorous responses when encountered within the nest. In other words how an ant responds to a certain stimulus often depends upon whether the ant is within or without the nest.

What is the cause of this crack-covering behavior? Three possible solutions suggest themselves: first, the covering of the crack is a reflex activity induced by draughts through the cracks affecting the ants within the nest; second, it is a reflex response caused by odors that emerge through the crack and stimulate passing ants to cover it with trash; third, it is a response due to certain ants grasping the fact that the crack needed to be closed and then proceeding to cover it. The last supposition predicates to them what Hobhouse would call a practical judgment.

If the first assumption be true, then all of the ants within the brood chamber should have been stimulated to do the same

thing. Such was not the case; for although there were about two hundred workers within the nest, never more than six were seen covering the crack at any one time. Sometimes it took the few ants employed several days to cover the cracks in a satisfactory manner; yet in no case did a larger number participate.

To test the second assumption two different kinds of experiments were performed. I shall first describe an experiment of the first kind. When all the ants were resting quietly within the nest the trash was gently removed from crack *e* (Fig. 2). The ants within the nest immediately became restless. Two of them mounted the ceiling and examined the crack carefully. About fifteen minutes later an ant was observed moving back and forth on top of the nest. On coming in contact with crack *e* it paused momentarily, examined the crack carefully and then passed on. After it had roamed about the island for a few minutes, I imprisoned it. About five minutes later another ant from the nest walked across the top of the nest to crack *e*. After examining the crack carefully with its antennæ, the ant began to cover the crack with trash. In a few minutes this ant was joined by a third. This experiment shows that all ants that cross the crack are not stimulated to do the same thing.

The second type of experiment was quite unlike this. As before, the trash was gently removed from crack *e* producing the same restlessness within. The cover was then removed from compartment *B* (Fig. 1) and several worker ants transferred to a beaker. The cover was then replaced on *B*.

One of the captured ants, after having been marked with a characteristic color was placed near the middle of the top of compartment *C* and covered with a transparent white glass cone eight centimeters in diameter. At first the ant would make vigorous efforts to escape from the cone. It would meander over the top of the nest, go repeatedly round and round the circumference of the base of the cone and sometimes mount its sides. In these random movements the ant would of necessity cross that crack many times. After more or less of this fruitless activity, the ant would become quieter. It would then move more leisurely about, examining the crack at frequent intervals or else it would rest over the crack or a short distance therefrom and quietly preen its

antennæ. When this condition of calm had been attained, which usually required about five minutes, the glass cone was quietly removed. Thus the confining cone was not removed until the ant had recovered from the excitement caused by the handling.[1] Now if contact with crack *e* or the odors ascending through it will induce ants reflexly to cover it with trash, then, when free to roam at large, the ant should have proceeded to cover the crack with trash. This was tried with twelve different ants, but in no case did the ant cover the crack with trash. In all cases the ant carefully examined the crack and in one case it tried to force its way through the crack into the nest. Sooner or later the ant would begin to roam about over the top of the nest and in some cases over the Lubbock island as well. After awhile it would enter the nest. Some ants entered the nest within a minute after the confining cone was removed, one spent two hours finding its way home, one became lost and the majority took less than three minutes to find the entrance to the nest. About an hour after the beginning of the experiment an unmarked worker from the nest began to cover the crack with trash, and by the close of the third day it had covered cracks *e* and *b* in the usual manner (Fig. 2).

Once or twice a week for several months I continued to remove the trash from crack *e*, soon after it had been completely covered. Each time the crack was recovered. On June 28, however, the ants not only covered the top of *e* with trash, but beneath *e*, on the inside, they built up a wall of detritus, through which a tunnel connected the two halves of compartment *C*. The outside cover was composed of a heterogeneous mass of coarse particles of various kinds and a few cotton fibers; the partition constructed on the inside consisted of a felted mass of cotton fibers and fine crumbs of bread. Nine times I destroyed this inner portion; each time it was reconstructed by the ants out of the same kind of material. The tunnel through the partition was sometimes located in one position and sometimes in another. The different partitions varied in width from one fourth to three

[1] Experiments recorded in my paper on "The Homing of Ants" show that the handling of ants to mark them with water colors does not alter their physiological attunement.

fourths of an inch; the tunnels through the partition varied in width from one half an inch to one half the length of the partition. The ants glued the partition to the roof in such a manner that no matter how wide the tunnel, the felted roof always completely closed the crack.

After the ants had begun to close the crack with the wall built up within from the floor, the crack *e* was thereafter only imperfectly covered with trash; furthermore, instead of covering the edges *b*, *c*, *d* and *f* with trash, the same result was obtained by chinking from inside the space between the glass cover and the top of the walls of the brood chamber with material similar to that with which they constructed the inner partition.

To see if all colonies of *Formica fusca* var. *subsericea* Say would behave in the same way in the presence of a crack across their brood chamber, a crack was made in the top of the brood chamber of each of four nests of this species. These nests were obtained from the field and housed in Janet nests for this special purpose. In two cases the ants with their young deserted the chamber over which I had placed a crack and migrated to the nest of another colony of the same species.[1] In one case the ants with their young migrated from the compartment over which I had placed a crack into another compartment of the same nest. I forced them back into chamber *C* by substituting a piece of colorless glass for the orange glass with which the chamber into which they had migrated was covered. They and their young remained thereafter in chamber *C* for six weeks without doing anything that tended to close up that crack. In the fourth case the ants with their young retreated from brood chamber *C*, over which I had placed a crack, into chamber *B*. I then placed a crack across chamber *B* and a complete cover over chamber *C*. At once the ants covered the crack with trash but no partition was constructed upon the inside.

It is convenient to group the responses of animals living in colonies into class responses and individualistic responses. A class response is a stereotyped response which would be made by any and each member of a group when confronted with similar

[1] The colony into which each of these colonies migrated contained, before the arrival of the emigrants, no fertile females.

stimuli. When, under identical conditions, one member of a group responds to a stimulus in one way and yet other members respond to a similar stimulus in a different manner the response would be individualistic. When an animal faces a situation for which it has no class response and yet almost immediately makes an individualistic response which overcomes the difficulty, it has formed what Hobhouse calls a practical judgment.

It seems to me that this is what the ants did in the case recorded here. When a crack was made into their brood chamber they were face to face with a situation for which they had no class response. After awhile one to a few individuals made individualistic responses which resulted in the closing of the crack. To those few ants the disturbance in the brood chamber had been associated with the unclosed crack. To them the crack had acquired a meaning. It had become a crack-to-be-closed and they proceeded to close it.

It is not claimed that the construction of a trash pile of heterogeneous material, nor even the building of a felted partition out of special materials, indicates the formation of a practical judgment; for the forming of a trash pile by ants is, and the modeling of a partition may be, an instinctive action. But the utilization of these instinctive activities, without a preliminary period of experimentation, to meet adequately conditions for which the ants had no stereotyped response is what warrants the assumption that they form practical judgments.

It seems to me that in constructing the partial bridge, in removing the guards from the entrance and plugging it with cotton, and in closing the crack to the brood chamber, at first with trash piled on the outside and later with a wall built up from within, the ants have responded to stimuli, not as ends in themselves, but rather as means to ends. This would lift the act out of the realm of instinctive behavior into that of the practical judgment.

HULL ZOÖLOGICAL LABORATORY,
UNIVERSITY OF CHICAGO, August 17, 1907.

EXPLANATION OF FIGURES.

Each represents a diagram of the top of a Janet nest: *A*, *B*, *C* are brood chambers; *D* is the water well; *E* is the entrance to the nest; *a*, *b* are cracks between the glass covers; *c*, *d*, *f* are edges of the glass cover of chamber *C*; *e* is a crack across the top of chamber *C*; the oblique shading represents the turkish toweling; the horizontal shading represents the glass covers.